

METHOD OF FABRICATING A LUBRICANT-INTEGRATED
LOAD/UNLOAD RAMP FOR A DISC DRIVE

by

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5 **METHOD OF FABRICATING A LUBRICANT-INTEGRATED**
 LOAD/UNLOAD RAMP FOR A DISC DRIVE

Related Applications

 This application claims priority of PCT application, Attorney Docket No.

10 STL9493PCT/40046.100WOU1 filed on February 5, 2001 and United States provisional
 application Serial Number 60/183,099, filed February, 17, 2000.

Field of the Invention

15 This application relates generally to magnetic disc drives and more particularly to a
 method of fabricating a lubricated load/unload ramp for use in a disc drive.

Background of the Invention

20 Disc drives are data storage devices that store digital data in magnetic form on a
 rotating storage medium on an information storage disc. Modern disc drives comprise one or
 more rigid information storage discs that are coated with a magnetizable medium and mounted
 on the hub of a spindle motor for rotation at a constant high speed. Information is stored on
 the discs in a plurality of concentric circular tracks typically by an array of transducers
 ("heads") mounted to a radial actuator for movement of the heads in an arc across the surface
 of the discs. Each of the concentric tracks is generally divided into a plurality of separately
 addressable data sectors. The recording transducer, e.g. a magnetoresistive read/write head, is
25 used to transfer data between a desired track and an external environment. During a write
 operation, data is written onto the disc track and during a read operation the head senses the
 data previously written on the disc track and transfers the information to a host computing
 system. The overall capacity of the disc drive to store information is dependent upon the disc
 drive recording density.

30 The transducers are mounted on sliders or heads via flexures at the ends of a plurality
 of actuator arms that project radially outward from the actuator body. The actuator body pivots
 about a shaft mounted to the disc drive housing at a position closely adjacent the outer extreme

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5 of the discs. The pivot shaft is parallel with the axis of rotation of the spindle motor and the discs, so that the transducers move in a plane parallel with the surfaces of the discs.

Typically, such rotary actuators employ a voice coil motor to position the transducers with respect to the disc surfaces. The actuator voice coil motor includes a coil mounted on the side of the actuator body opposite the transducer arms so as to be immersed in the magnetic
10 field of a magnetic circuit comprising one or more permanent magnets and magnetically permeable pole pieces. When controlled direct current (DC) is passed through the coil, an electromagnetic field is set up which interacts with the magnetic field of the magnetic circuit to cause the coil to move in accordance with the well-known Lorentz relationship. As the coil moves, the actuator body pivots about the pivot shaft and the transducers move across the disc
15 surfaces. The actuator thus allows the transducer to move back and forth in an accurate fashion between an inner radius and an outer radius of the discs.

When a stop-start contact disc drive is de-energized, the transducers are automatically moved to a storage location or "park" location on the disc surfaces. The park location is typically adjacent and outside the inner or outer periphery of the data storage region of the disc
20 and is typically called a landing zone. This landing zone typically does not contain any useable data as the transducer physically contacts the disc at rest. Consequently, any data stored in this area would likely be lost or compromised. In addition, the landing zone is typically roughened to minimize the stiction of the transducer against the disc surface.

Alternatively, disc drives may utilize load/unload ramps to facilitate removal of the
25 transducers from the discs to a parked position adjacent the discs. The load/unload ramps in a disc drive are typically stationary, such that in the process of the suspension assemblies being unloaded from the disc, the transducers are moved to the outer rim portion of the discs and onto ramps which extend over the outer rim portions of the disc. The transducers then traverse up the load/unload ramps to a park location off of the disc surfaces. In the reverse process, the
30 transducers are loaded onto the disc by the transducers moving down the stationary ramps onto the media.

The use of a load/unload ramp to store the transducer under de-energized conditions has several advantages over the use of the traditional landing zone on the disc surface. First, using a load/unload ramp eliminates stiction concerns and friction failures associated with the transducer

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5 being de-energized on the landing zone of the disc. Second, information storage disc have a protective carbon overcoat which is at least in part required to support the transducer-landing zone interaction. In the absence of this interaction, a thinner carbon overcoat may be utilized on the disc surface. A thinner carbon overcoat on the information storage disc allows for the design of decreased transducer-to-disc media spacing and for corresponding increased recording density.

10 Finally, by parking the transducer head off the information storage disc surface on the load/unload ramp, a larger amount of disc space is available for data storage, which results in increased recording density.

However, the use of a load/unload ramp in a disc drive has several disadvantages, one of which is that the numerous interactions between the load/unload ramp and

15 transducer/suspension assembly presents a tribological problem involving friction, lubrication and wear on the surfaces of both the load/unload ramp and transducer/suspension assembly. Ultimately, the level of friction between the surfaces of the load/unload ramp and transducer/suspension assembly determines the wear on those surfaces and ultimately to the formation of debris off of those surfaces and into the disc drive. Debris formation inside the

20 disc drive is a major concern in the disc drive industry. Thus, minimizing friction between the load/unload ramp and the transducer/suspension assembly is a major concern in the disc drive art.

Presently, friction between the load/unload ramp and transducer/suspension assembly is minimized by forming the ramp out of a low friction-low wear plastic and by lubricating the

25 transducer/suspension assembly or more preferably the load/unload ramp with a Teflon™ based lubricant. However, administering the proper amount of lubricant on the load ramp surfaces and of manufacturing a cost effective load/unload ramp with a lubricant film continues to present shortcomings in disc drive art. Against this backdrop the present invention has been developed.

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Summary of the Invention

In accordance with the present invention the above problems and others have been solved by molding a load/unload ramp using a disc drive compatible lubricant as the mold releasing agent.

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5 One embodiment of the present invention is a method for fabricating a load/unload ramp for a disc drive. The method includes providing a mold having a cavity shaped for forming a load/unload ramp and coating surfaces of the cavity with an amount of a disc drive compatible lubricant. The disc drive compatible lubricant acts as a releasing agent and is effective at providing a layer of lubricant at a predetermined thickness on the fabricated load/unload ramp.

10 The method further includes injecting a polymer melt into the lubricant coated cavity, solidifying the polymer melt to form the molded load/unload ramp in the cavity, and releasing the molded load/unload ramp from the cavity.

15 Another embodiment of the present invention is an alternative method for fabricating a load/unload ramp for a disc drive. The method includes providing a mold having a load/unload ramp shaped cavity, plasticizing a polymer to form a polymer melt, and mixing the polymer melt with a disc drive compatible lubricant. The disc drive compatible lubricant is used as a releasing agent and is effective in providing a layer of lubricant a predetermined thickness on the fabricated load/unload ramp. The method further includes injecting the mix into the mold cavity and allowing it to solidify in the cavity. Finally, the fabricated load/unload ramp is released from the mold cavity.

20 These and various other features as well as advantages which characterize the present invention will be apparent from a reading of the following detailed description and a review of the associated drawings.

25 **Brief Description of the Drawings**

FIG. 1 is a plan view of a disc drive incorporating a preferred embodiment of the present invention showing the primary internal components.

FIG. 2 is an exploded perspective view of a load/unload ramp in accordance with a preferred embodiment of the present invention.

30 FIG. 3 is a representative cross section through a load/unload ramp in accordance with a preferred embodiment of the present invention.

FIG 4 is a representative cross section through a load/unload ramp mold in accordance with a preferred embodiment of the present invention.

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5 FIG **5** is a flow chart of the method of fabricating a load/unload ramp in accordance with a preferred embodiment of the present invention.

FIG. **6** is a flow chart of the method of fabricating a load/unload ramp in accordance with a second preferred embodiment of the present invention.

Detailed Description

10 A disc drive **100** constructed in accordance with a preferred embodiment of the present invention is shown in FIG. **1**. The disc drive **100** includes a base **102** to which various components of the disc drive **100** are mounted. A top cover (not shown) cooperates with the base **102** to form an internal, sealed environment for the disc drive in a conventional manner. The
15 components include a spindle motor **104** which rotates one or more discs **106** at a constant high speed. Information is written to and read from tracks **108** on the discs **106** through the use of an actuator assembly **110**, which rotates during a seek operation about a bearing shaft assembly **112** positioned adjacent the discs **106**. The actuator assembly **110** includes a plurality of actuator arms **114** which extend towards the discs **106**, with one or more flexures **116** extending from
20 each of the actuator arms **114**. Mounted at the distal end of each of the flexures **116** is a head **118** which includes an air bearing slider (not shown) enabling the head **118** to fly in close proximity above the corresponding surface of the associated disc **106**. Additionally, extending substantially laterally from the distal end of the flexure **116** is a lift tab (not shown) for engagement with a load/unload ramp **120** as is described in greater detail below.

25 During a seek operation, the track position of the heads **118** is controlled through the use of a voice coil motor (VCM) **122**, which typically includes a coil **124** attached to the actuator assembly **110**, as well as one or more permanent magnets **126** which establish a magnetic field in which the coil **124** is immersed. The controlled application of current to the coil **124** causes magnetic interaction between the permanent magnets **126** and the coil **124** so that the coil **124**
30 moves in accordance with the well known Lorentz relationship. As the coil **124** moves, the actuator assembly **110** pivots about the bearing shaft assembly **112**, and the heads **118** are caused to move across the surfaces of the discs **106**.

The spindle motor **104** is typically de-energized when the disc drive **100** is not in use for extended periods of time. The heads **118** are moved over the surfaces of the discs **106** to

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5 the load/unload ramp **120** located adjacent the outer periphery **128** of the information storage discs **106**. The heads **118** traverse onto the load/unload ramp **120** and are secured in position through the use of an actuator latch arrangement (not shown), which prevents inadvertent rotation of the actuator assembly **110** when the heads **118** are parked on the load/unload ramps **120**,

10 A flex assembly **132** provides the requisite electrical connection paths for the actuator assembly **110** while allowing pivotal movement of the actuator assembly **110** during operation. The flex assembly **132** includes a printed circuit board (not shown) to which head wires (not shown) are connected; the head wires being routed along the actuator arms **114** and the flexures **116** to the heads **118**. The printed circuit board **134** typically includes circuitry for controlling the
15 write currents applied to the heads **118** during a write operation and a preamplifier for amplifying read signals generated by the heads **118** during a read operation. The flex assembly terminates at a flex bracket (not shown) for communication through the base deck **102** to a disc drive printed circuit board (not shown) mounted to the bottom side of the disc drive **100**.

20 As briefly discussed above, the disc drive **100** has a load/unload ramp **120** in accordance with a preferred embodiment of the present invention for securing a head **118** off the disc **106** during a shutdown or standby condition. Because the actuator assembly **110** moves back and forth in an arcuate fashion between an inner radius and an outer radius of the disc **106**, the load/unload ramp **120** has a generally arcuate shape that aligns and lays in the path of the movement of the distal tip of the actuator assembly **110** when the actuator arm **114**
25 swings to the outer diameter **128** of the disc **106**.

Fig. **2** is a perspective view of the load/unload ramp **120**. The load/unload ramp **120** is typically secured to the base plate **102** adjacent the outer periphery **128** of the information storage disc **106** so that the load/unload ramp **120** does not interfere with the operation of the head **118**. The structure of the load/unload ramp **120** includes a pick-up portion **138**, adjacent
30 the outer diameter **128** of the information storage disc **106**, and a storage portion **140** that extends away from the information storage disc **106**. The pick-up portion **138** forms a generally curved wedge like structure having an inclined surface **142** for sliding engagement typically with a lift tab (not shown) of the flexure **116**.

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5 Extending distally away from the pick-up portion **138** of the load/unload ramp **120** is a generally flat storage portion **140** of the load/unload ramp **120**. In general, the storage portion **140** of the load/unload ramp **120** is a solid body having a side surface that is curved complementary with the arcuate movement of the actuator assembly **110**. The storage portion **140** extends in a vertical direction slightly above and adjacent the top end **144** of the inclined surface **142** to form a wall or face **146**. A horizontal groove or slot **150** is formed in one side **148** of the storage portion **140** that extends from the wall **146**, along the length of the storage portion **140**, to the distal end **152** of the storage portion **140**. The bottom surface **154** of the groove **150** is substantially parallel to the plane or rotation of the actuator and aligns with the top end **144** of the ramp face **142** of the pick-up portion **138**. The depth and height of the groove **150** is generally uniform and should preferably be sufficient for the acceptance of the flexure lift tab (not shown) so that when the actuator is rotated away from the disc **106**, the flexure left tab rides up the inclined surface **142** directly into and along the groove **150**. The groove **150** functions to support the lift tab and prohibit vertical movement of the lift tab by confining the lift tab in the groove during a shock event or during normal disc drive shut down and standby conditions.

It should be noted that embodiments of the present invention are not limited to load/unload ramps designed to secure actuator assemblies on only one side of an information storage disc. Embodiments of the present invention can function when the load/unload ramp is configured to secure two actuator assemblies, one assembly operating on the top side of an information storage disc and a second actuator assembly operating on the bottom side of the same information storage disc (see Fig. 3). As such, the above description of the load/unload ramp structure is for illustrative purposes only. Any load/unload ramp structure that interacts with the actuator assembly to remove the head from the information storage disc surface is within the scope of the present invention as the inventive features of embodiments of the present invention address structurally independent features of the load/unload ramp.

A cross section of the load/unload ramp **120** that lifts the heads **118** from the top and bottom sides of a disc **106** taken along the line **3-3** of Fig. 1 is shown in Fig. 3. The load/unload ramp **120** is preferably composed of any disc drive compatible polymer. Typical polymers for use with embodiments of the present invention are low friction-low wear plastics.

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- 5 Low friction-low wear plastics include, but are not limited to, members of the Liquid Crystal Polymer family, such as Vectra A430 (manufactured by Ticona), etc.

A thin layer **156** of lubricant coats the load/unload ramp **120** to minimize the friction coefficient between the lift tab and the polymer surface of the load/unload ramp. Friction coefficients below 0.2 and preferably below 0.15 are required for optimal lift tab-load/unload ramp interactions. Lubricants for use with embodiments of the present invention must be
10 compatible with the disc drive **100** and can include, but are not limited to, perfluoropolyether, derivatives of perfluoropolyether, 2-Tetraol, 2-Dol, etc.

The method of fabricating the load/unload ramp **120** involves the use of a disc drive **100** compatible lubricant, like perfluoropolyether, as a mold release agent during a molding process of the load/unload ramp. A load/unload ramp mold **158** is shown in Fig. **4**. The mold **158** has a load/unload ramp shaped cavity **160** and surrounding surfaces **162** for withstanding the temperatures and pressures required to form the resultant load/unload ramp **120**.
15 Additionally, an opening in the mold provides the injection gate **164** for the mold cavity **160**.

At the beginning of each molding cycle a controlled amount of disc compatible
20 lubricant is applied to the mold cavity **160** in which the load/unload ramp **120** is formed. The thickness of the lubricant layer on the finished load/unload ramp **120** is dependent on the amount of lubricant inserted into the mold cavity **160**. Typically, the thickness of the lubricant layer on the resulting load/unload ramp **120** needs to be between about 200 Å and about 500 Å, and preferably between about 200 Å and about 350 Å, and most preferably between about
25 200 Å and about 250 Å. Lubricant layers thicker than about 550 Å tend to lead to the formation of lubricant droplets that can contaminate the disc drive **100**. Alternatively, a lubricant layer that is less than about 150 Å tends not to provide adequate lubricant properties to the surface of the load/unload ramp **120**. Application of the lubricant to the mold cavity **160** prior to melt injection of the load/unload ramp polymer is preferably done by spraying the
30 lubricant onto the inside mold cavity surfaces **166**, although any standard technique for applying a releasing agent to a mold cavity wall may be used.

The low friction-low wear polymer, *i.e.*, liquid crystal polymer, is heated to a temperature of approximately 290°C to form a substantially homogenous polymer melt material. Plasticized polymer melt material is injected through the gate **164** into a pre-

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5 lubricated cavity **160** having a controlled or known amount of disc drive compatible lubricant applied to the cavity surfaces **166**. The polymer melt is injected under pressure until the mold cavity **160** is filled. The polymer melt is then allowed to polymerize and cool. The rate of cooling may be accelerated or controlled as is well known within the art. Once the load/unload ramp material is cooled and solidified in the mold **158** it is removed from the mold
10 cavity **160** using the disc drive compatible lubricant as the releasing agent.

Alternatively, it is envisioned that a similar lubricant layer and lubricant layer thickness can be obtained on the finalized load/unload ramp surfaces by blending or mixing the disc drive compatible lubricant and load/unload ramp polymer melt during the melt preparation stage of the molding process. In this case, the process described above would be similar
15 except that the load/unload ramp material and controlled amount of disc drive compatible lubricant would be pre-mixed in a plasticized form and then injected under pressure into an unlubricated or minimally lubricated load/unload ramp mold cavity. The load/unload ramps **120** formed in this fashion advantageously have lubricant dispersed throughout the resulting load/unload polymer. The lubricant constituent of the melt may be approximately 0.5 to 3%,
20 although other lubricant concentrations are envisioned to be within the present invention.

It can be appreciated that other constituents may be added to the polymer or polymer/lubricant mix, to form a load/unload ramp composition having modified characteristics. An example of one such constituent is a load/unload ramp polymer/lubricant composition containing a surfactant for facilitating the uniformity at which the lubricant is
25 disposed within the polymer.

One method for fabricating a load/unload ramp **120** in conformity with the present invention is shown in Fig. **5**. In operation **500**, a load/unload ramp mold is provided. Process control transfers to Operation **501**. In Operation **501**, the load/unload ramp mold is opened. Process control then transfers to Operation **502**. In Operation **502**, a controlled amount of disc
30 compatible lubricant is applied to the load/unload ramp mold cavity surfaces. Process control then transfers to Operation **504**. In Operation **504**, the load/unload ramp polymer is heated and injected or poured into the load/unload ramp cavity. Process control then transfers to Operation **506**. In Operation **506**, the load/unload ramp material is allowed to polymerize and cool. Process control then transfers to Operation **508**. In Operation **508**, the molded

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5 load/unload ramp is released from the mold using the disc drive compatible lubricant as the mold releasing agent.

Another method for fabricating the load/unload ramp in conformity with the present invention is shown in Fig. 6. In Operation **600**, a load/unload ramp mold is provided. Process control transfers to Operation **602**. In Operation **602**, the polymer used to form the
10 load/unload ramp is plasticized, forming a polymer melt. Process control transfers to Operation **604**. In Operation **604**, the polymer melt is mixed with a disc drive compatible lubricant that acts as a releasing agent and is effective in providing a layer of predetermined thickness on the fabricated load/unload ramp. Process control transfers to Operation **606**. In Operation **606**, the polymer melt - lubricant mix is injected into the mold cavity. Process
15 control then transfers to Operation **608**. In Operation **608**, the mix is allowed to solidify and form the molded load/unload ramp in the cavity. Process control then transfers to Operation **610**. In Operation **610**, the molded or fabricated load/unload ramp is released from the cavity.

In summary, a preferred embodiment of the invention described herein is directed to a method for fabricating a load/unload ramp (such as **120**) for a disc drive (such as **100**). The
20 method includes providing a mold (such as **158**) having a cavity (such as **160**) therein shaped for forming a load/unload ramp (such as **120**) (such as in step **500**). Next, surfaces (such as **166**) in the cavity (such as **160**) are coated with an amount of a disc drive compatible lubricant that acts as a releasing agent effective to provide a layer (such as **156**) of predetermined thickness on the fabricated load/unload ramp (such as in step **502**). A polymer melt is injected into the lubricant
25 coated cavity (such as **160**) (such as in step **504**). The polymer melt is solidified to form the molded load/unload ramp (such as **120**) in the cavity (such as **160**) (such as in step **506**). Finally, the molded load/unload ramp (such as **120**) is released from the cavity (such as **160**) (such as in step **508**).

In another preferred embodiment of the invention, the method further includes selecting
30 the disc drive compatible lubricant from the perfluoropolyether family.

In another preferred embodiment of the invention, the method further includes using an amount of disc drive compatible lubricant that is effective in providing a layer of predetermined thickness between about 200 Å and about 500 Å.

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5 In another preferred embodiment of the invention, the method further includes using an amount of disc drive compatible lubricant that is effective in providing a layer of predetermined thickness between about 200 Å and about 350 Å.

 In another preferred embodiment of the invention, the method further includes using an amount of disc drive compatible lubricant that is effective in providing a layer of predetermined
10 thickness between about 200 Å and about 250 Å.

 In another preferred embodiment of the invention, the method further includes a liquid crystal polymer as the polymer melt.

 Another preferred embodiment of the invention described herein is directed to a second method for fabricating a load/unload ramp (such as **120**) for a disc drive (such as **100**). The
15 method includes providing a mold (such as **158**) having a load/unload ramp shaped cavity (such as **160**) (such as in step **600**) and of plasticizing a polymer to form a polymer melt (such as in step **602**). Next, the polymer melt and a disc drive compatible lubricant are mixed such that the disc drive compatible lubricant is effective in providing a layer (such as **156**) of predetermined thickness on the fabricated load/unload ramp (such as in step **604**). The mixture is then injected
20 into the mold cavity (such as in step **606**). Finally, the mixture is allowed to solidify in the cavity (such as in step **608**) and the fabricated load/unload ramp is released from the cavity (such as in step **610**).

 In another preferred embodiment of the invention, the method further includes selecting perfluoropolyether as the disc drive compatible lubricant.

25 In another preferred embodiment of the invention, the method further includes using an amount of disc drive compatible lubricant that when mixed with the polymer melt is effective in providing a lubricant layer of predetermined thickness between 200 Å and 500 Å.

 In another preferred embodiment of the invention, the method further includes using an amount of disc drive compatible lubricant that when mixed with the polymer melt is effective in
30 providing a lubricant layer of predetermined thickness between 200 Å and 350 Å.

 In another preferred embodiment of the invention, the method further includes using an amount of disc drive compatible lubricant that when mixed with the polymer melt is effective in providing a lubricant layer of predetermined thickness between 200 Å and 250 Å.

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5 It will be clear that the present invention is well adapted to attain the ends and advantages mentioned as well as those inherent therein. While a presently preferred embodiment has been described for purposes of this disclosure, various changes and modifications may be made which are well within the scope of the present invention. Numerous other changes may be made which will readily suggest themselves to those skilled in the art and which are encompassed in the spirit
10 of the invention disclosed and as defined in the appended claims.

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